Induction of atrial fibrillation with rapid high voltage ventricular pacing for ventricular fibrillation conversion testing

A Schuchert, M Kühl, R Rüppel, T Meinertz, on behalf of the Ventak AV II DR Study Group

Abstract

Objective—To assess whether rapid high voltage ventricular pacing can also induce atrial fibrillation, and whether the induction of atrial fibrillation during ventricular fibrillation conversion testing is related to the patient's heart disease.

Design—Prospective study of 50 patients who received the dual chamber implantable cardioverter-defibrillator (ICD) Ventak AV II DR (Guidant) as a first implant. This device can record atrial activity even during a ventricular fibrillation episode and can induce atrial fibrillation by rapid atrial bursts.

Main outcome measures—Frequency of atrial fibrillation after induction of ventricular fibrillation; clinical characteristics of patients with and without induced atrial fibrillation; frequency of atrial fibrillation induced by rapid atrial bursts during predischarge testing.

Results—Atrial fibrillation was observed in 40 of the 217 ventricular fibrillation episodes (18%) that could be detected immediately after delivery of high voltage pacing. The biphasic ICD shock for termination of ventricular fibrillation also terminated the atrial fibrillation in all cases. The 40 episodes of simultaneous atrial and ventricular fibrillation occurred in 18 patients (36%). The distribution of the clinical characteristics of the patients and the inducibility of atrial fibrillation during predischarge testing were similar in those with and without induced atrial fibrillation.

Conclusions—Rapid high voltage ventricular pacing frequently induces atrial fibrillation, which was terminated by the subsequent biphasic ICD shock. The induction of atrial fibrillation seems to be a non-specific phenomenon, unrelated to the clinical status of the patient.

(*Heart* 2000;**83**:178–180)

Keywords: dual chamber implantable cardioverter-defibrillator; atrial fibrillation induction; ventricular fibrillation conversion test; high voltage ventricular pacing; atrial burst pacing

Medical Clinic, Department of Cardiology, University Hospital Eppendorf, Martinistrasse 52, D-20246 Hamburg, Germany
A Schuchert
R Rüppel
T Meinertz

Guidant CPI, Brussels, Belgium
M Kühl

Correspondence to:
Dr Schuchert

Accepted 16 August 1999

The verification of effective termination of ventricular fibrillation is one of the crucial issues during the implantation of a cardioverter/defibrillator (ICD). One well established method for induction of ventricular fibrillation is the delivery of rapid high voltage pacing pulses to the ventricle. Little is known about the effect of this stimulus on the atrial myocardium, especially its ability to induce atrial fibrillation.[1] One reason for this is the methodological limitation which makes it impossible to assess atrial activity from the surface ECG during an episode of ventricular fibrillation. New dual chamber ICDs, which are connected to both a ventricular and an atrial pacing lead, enable atrial activity to be monitored continuously during an episode of ventricular fibrillation. Our aim in this study was to describe the frequency of atrial fibrillation induced by the delivery of rapid high voltage pacing pulses during ventricular fibrillation conversion testing in patients undergoing an ICD implantation. Patients with and without induced atrial fibrillation were also compared to assess whether the induction of atrial fibrillation is related to the patient's heart disease.

Methods

PATIENTS

Patients with the indication for an initial ICD implant were enrolled in 18 European centres for the clinical evaluation of the new dual chamber ICD Ventak AV II DR (Guidant, St Paul, Minnesota, USA). The findings concerning the device detection and treatment will be presented separately.

DEVICE

The Ventak AV II DR is a dual chamber, three electrode (device electrically active) ICD. The device was connected to the defibrillation lead (Guidant), which was placed in the right ventricle, and to the Sweet Tip pacing lead (Guidant) with active fixation in the atrium. The extended telemetry facilities of the ICD allow monitoring of ventricular and atrial activities simultaneously. The ICD can deliver both high voltage pacing pulses to the ventricle and rapid burst pacing in the atrium for electrophysiological testing.

IMPLANTATION

After lead implantation and connection to the ICD, ventricular fibrillation conversion testing was performed. The ventricular fibrillation induction method was to deliver rapid high voltage pacing pulses with 7.5 V pulse amplitude at 1.0 ms pulse duration and 50 Hz for three to five seconds. The induced ventricular fibrillation was detected by the ICD and subsequently terminated by biphasic shocks. The defibrillation threshold was established according to a step down protocol (< 5, 6, 7, 9, 11, 14, and 17 J) or by verification of a

sufficient converting energy, as defined in the study protocol (that is, two successes at 17 joules stored.)

PREDISCHARGE TEST

Predischarge testing included the induction of atrial fibrillation by rapid atrial bursts. Atrial pacing with 5.0 V pulse amplitude and 0.5 ms pulse duration began at 300 ms, with progressively shorter coupling intervals of 20 ms decrements until a lack of atrial capture was observed. At the end of predischarge testing ventricular fibrillation was induced to verify the energy requirements for arrhythmia termination.

ANALYSIS

The frequency of atrial fibrillation induced by rapid high voltage pacing was recorded. Patients in whom ventricular fibrillation as well as atrial fibrillation was induced (with AF group) were compared with those with no atrial fibrillation (no AF group) for clinical characteristics and the inducibility of atrial fibrillation by rapid atrial pacing during predischarge testing.

STATISTICS

Statistical analyses were performed with the two sided Student's *t* test and the Fisher test. Probability (p) values less than 0.05 were considered statistically significant.

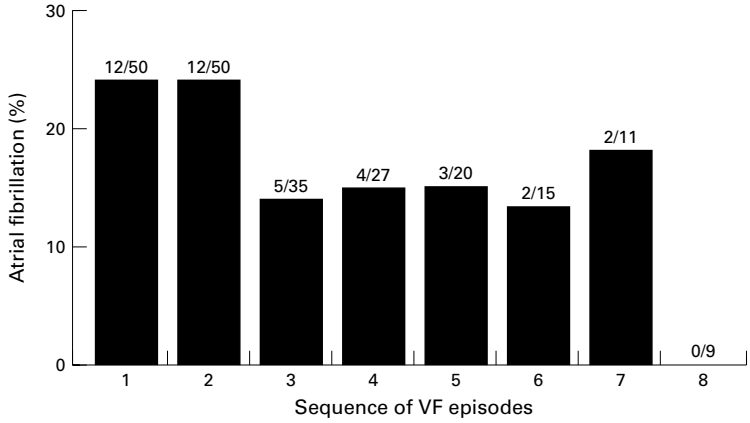

Figure 1 Atrial fibrillation during each episode of ventricular fibrillation (VF).

Table 1 Clinical data of patients with and without atrial fibrillation during intraoperative ventricular fibrillation (VF) conversion testing

	With AF	*No AF*	
Patients	18	32	
Male	16 (89)	28 (88)	NS
Age (years) (mean (SD))	63 (12)	57 (11)	NS
Coronary heart disease	13 (72)	19 (59)	NS
History of atrial fibrillation	4 (22)	6 (19)	NS
Left ventricular ejection fraction (%) (mean (SD))	39 (17)	34 (14)	NS
NYHA I + II	13 (72)	24 (75)	NS
NYHA III + IV	5 (28)	8 (25)	NS
Primary arrhythmia			
MVT	8 (44)	17 (53)	NS
VF	10 (56)	15 (47)	NS
Antiarrhythmic drugs			
Class I	0	3 (9)	NS
Class II	3 (17)	3 (9)	NS
Class III (sotalol)	2 (11)	4 (13)	NS
Class III (amiodarone)	3 (17)	5 (16)	NS

Values are n (%) unless otherwise stated.
AF, atrial fibrillation; MVT, monomorphic ventricular tachycardia, NYHA, New York Heart Association functional class.

Results

We enrolled 52 patients. Two were excluded from the analysis because of chronic atrial fibrillation.

A defibrillation threshold was established in 26 patients according to the step down protocol, and a sufficient level of converting energy was verified in 24. There were 217 ventricular fibrillation episodes, which were terminated by a subsequent device shock. Fifteen patients had two inductions, eight had three, seven had four, four had five, five had six, two had seven, and nine had eight.

After the delivery of rapid ventricular pacing, atrial fibrillation was observed in 40 of the 217 ventricular fibrillation episodes (18%). Atrial fibrillation was present immediately after the delivery of the high voltage pacing and seemed to be induced by the atrial capture of the high voltage pacing pulses. The duration of high voltage pacing was not related to the incidence of atrial fibrillation. The subsequent biphasic ICD shock terminated all episodes of atrial fibrillation. During the first two ventricular fibrillation inductions the frequency of atrial fibrillation was 24% and ranged from 13% to 18% for the subsequent ventricular fibrillation inductions (fig 1).

The 40 episodes of atrial and ventricular fibrillation occurred in 18 of the 50 patients (36%). These patients each had a mean (SD) of 2.2 (1.3) episodes of atrial fibrillation (range 1 to 6). The first occurrence of atrial fibrillation was during the first or second induction of ventricular fibrillation in 17 of these patients and during the fourth induction in one. The clinical characteristics—including a history of paroxysmal atrial fibrillation—of the 18 patients with induced atrial fibrillation did not differ from those of the 32 patients without atrial fibrillation (table 1).

Atrial fibrillation induced by rapid burst pacing in the atrium was observed in 33 patients during predischarge testing. The frequency of atrial fibrillation was similar in patients with evidence of atrial fibrillation during ICD implantation (13/18; 72%) and in patients without a history of atrial fibrillation (20/32; 63%) (p = 0.55).

Discussion

Programmed atrial stimulation is commonly used to induce atrial fibrillation in humans.[2–5] This technique, however, is not always sufficient to induce the arrhythmia in all patients. A more reliable protocol, which is often used in animals, is the delivery of 50 Hz pacing pulses to the atrium.[1] Similar techniques for the delivery of rapid high voltage pacing pulses to the ventricle are well established for the induction of ventricular fibrillation in patients undergoing ICD implantation.

Arrhythmic effects on the atrium have been observed from the delivery of ICD treatment.[6–8] The arrhythmic effects of ventricular induction techniques for the atrium have not been thoroughly studied. An ICD shock can sometimes induce atrial fibrillation, which is presumably related to delivery of energy within the atrial vulnerable period.[6] In two studies, an

induction of atrial fibrillation was observed after the application of low energy shocks.[7 9] In addition, lead systems that include an electrode within the right atrium seem prone to inducing atrial fibrillation.[7 8]

In the present study, rapid high voltage ventricular pacing with an extended bipolar configuration induced atrial fibrillation with modest frequency. The mechanism seems to be primarily atrial capture; no retrograde conduction was observed. Nevertheless, the frequency of induced atrial fibrillation was nearly similar to the occurrence reported with low energy shocks, and subsequent high energy ICD shocks terminated the atrial fibrillation in all cases.[7] All but one of the patients who were inducible had their first episode of atrial fibrillation within the first or second ventricular fibrillation induction. Although this seems to indicate that some patients are more prone to the induction of atrial fibrillation, its inducibility was neither related to the patient's heart disease nor to the history of paroxysmal atrial arrhythmia or its inducibility by rapid atrial pacing. Other investigators have also been unable to determine identifying factors in patients with inducible atrial fibrillation.[7 8]

LIMITATIONS

The atrial pacing lead was necessary to record the atrial activity during ventricular fibrillation, but it may have facilitated the induction of atrial fibrillation.[7] Because of the immediate termination of atrial fibrillation by device shock we could not assess whether the induced atrial fibrillation would be sustained and later terminate spontaneously.

CONCLUSIONS

Rapid high voltage ventricular pacing for ventricular fibrillation induction during ICD implantation was often capable of inducing atrial fibrillation through atrial capture; this was terminated by the subsequent ICD shock. Although some patients seem prone to this induction, we were unable to predict it from the variables studied.

We would like to thank the members of the Ventak AV II DR Study Group: Auricchio Madgeburg D, Block Münster D, Capucci Piacenza I, den Dulk Maastricht NL, Favale Bari I, Glickson Tel Hashomer I, Herse Göttingen D, Himmrich Mainz D, Hohnloser Frankfurt D, Jung Bonn D, Kacet Lille Cedex F, Neuzner Bad Nauheim D, Schuchert Rüppel Hamburg D, Schalij Leiden NL, Schmidinger Wien A9.

1 Osswald S, Trouton TG, Roelke M, *et al*. Transvenous single lead atrial defibrillation: efficacy and risk of ventricular fibrillation in an ischemic canine model. *PACE* 1998;**21**:580–9.
2 Kühlkamp V, Meerhof J, Schmidt F, *et al*. Electrophysiologic effects and efficacy of cibenzoline on stimulation-induced atrial fibrillation and flutter and implications for treatment of paroxysmal atrial fibrillation. *Am J Cardiol* 1990;**65**:628–32.
3 Cosio FG. Atrial vulnerability. *Clin Cardiol* 1992;**15**:198–202.
4 Papageorgiou P, Anselme F, Kirchhof CJ, *et al*. Coronary sinus pacing prevents induction of atrial fibrillation. *Circulation* 1997;**96**:1893–8.
5 Manolis AS, Cameron J, Deering T, *et al*. Sensitivity and specificity of programmed atrial stimulation for induction of supraventricular tachycardias. *Clin Cardiol* 1988;**11**:307–10.
6 Jones GK, Johnson G, Troutman C, *et al*. Incidence of atrial fibrillation following ventricular fibrillation with transvenous lead system in man. *J Cardiovasc Electrophysiol* 1992;**3**:411–17.
7 Florin TJ, Weiss DN, Peters RW, *et al*. Induction of atrial fibrillation with low-energy defibrillator shocks in patients with implantable cardioverter defibrillators. *Am J Cardiol* 1997;**80**:960–2.
8 Katz A, Evans JJ, Fogel RI, *et al*. Atrial fibrillation/flutter induced by implantable ventricular defibrillator shocks: difference between epicardial and endocardial energy delivery. *J Cardiovasc Electrophysiol* 1997;**8**:35–41.
9 Chen PS, Shibota N, Dixon EB, *et al*. Comparison of defibrillation threshold and the upper limit of ventricular vulnerability. *Circulation* 1986;**73**:1022–8.